WACOM PRODUCTS

# BpBr Circuit®
# BANDPASS-REJECT DUPLEXER

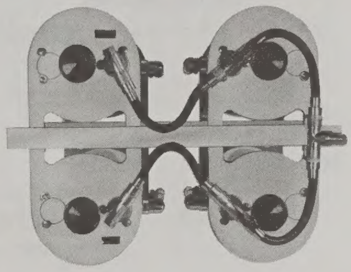
MIN. FREQ. SPACING: 1.0 MHz POWER: TO 350 WATTS

# WP-652
# WP-653

## 220-300 MHz

U. S. PATENT
NO. 4,080,601

**THESE BpBr CIRCUIT® DUPLEXERS** include the use of an exclusive circuit developed by Wacom Products which provides superior suppression of spurious sideband noise between and adjacent to the duplex frequencies. When used with a high Q cavity, the BpBr Circuit provides frequency response curves with bandpass cavity characteristics at the frequency to be passed and band-reject cavity characteristics at the frequency to be attenuated. Performance characteristics improve as the frequency separation is increased. Frequency stability of the BpBr Circuit duplexer is excellent—an important factor at close frequency spacing. Each model will handle transmitter powers up to 350 watts and all models are supplied with complete cable harness and mounting frame.



**ADVANTAGES OF THE BpBr CIRCUIT®:** Assuming a given insertion loss at the pass frequency, the BpBr Circuit filter provides superior bandpass characteristics near the pass frequency and a significantly wider notch at the frequency to be attenuated when compared with other types of bandpass-reject filters. These features result in superior transmitter to receiver isolation, superior protection to and from other nearby radio systems, and a greater stability over a wide temperature range. In addition field tuning of a BpBr Circuit filter is considerably easier than field tuning of most other types of bandpass-reject filters.

**MODEL WP-652** is designed for use with duplex stations operating in the 220-300 MHz band when the separation between transmit and receive frequencies is 1.0 MHz or more. It consists of four 5″ OD cavities interconnected with double shielded coaxial cable in a bandpass-reject configuration. It is generally suitable for use with all types of duplex stations, particularly the latest solid state types which require attenuation of transmitter sideband noise over a wide portion of the spectrum.

MODEL WP-652

**MODEL WP-653** is a six-cavity version of the above model. It consists of two bandpass-reject cavities and one bandpass cavity in each section of the duplexer. The bandpass cavity in each section provides an additional margin of protection to and from other nearby systems. This feature is especially important if this system is to be operated in a "hostile" site where numerous other transmitters and receivers are in use.

**TUNING:** The duplexer is factory tuned to the exact transmit and receive frequencies prior to shipment from the factory. No further field adjustment is normally required. If desired, the duplexer can be field tuned to new frequencies within its operating band by rotating the threaded tuning rod ("pass" frequency alignment) and adjusting the length of the adjustable stub ("reject" frequency alignment) of each filter.

**INSTALLATION:** The duplexer can be mounted in any position but is normally mounted vertically, with the tuning rods up. Double-shielded coaxial cable (such as RG-214 or RG-142) must be used to interconnect the duplexer to the transmitter and receiver chassis if maximum isolation is to be maintained. A suitable duplexer installation cable kit (Part No. 30090) is available as an optional item.

MODEL WP-653

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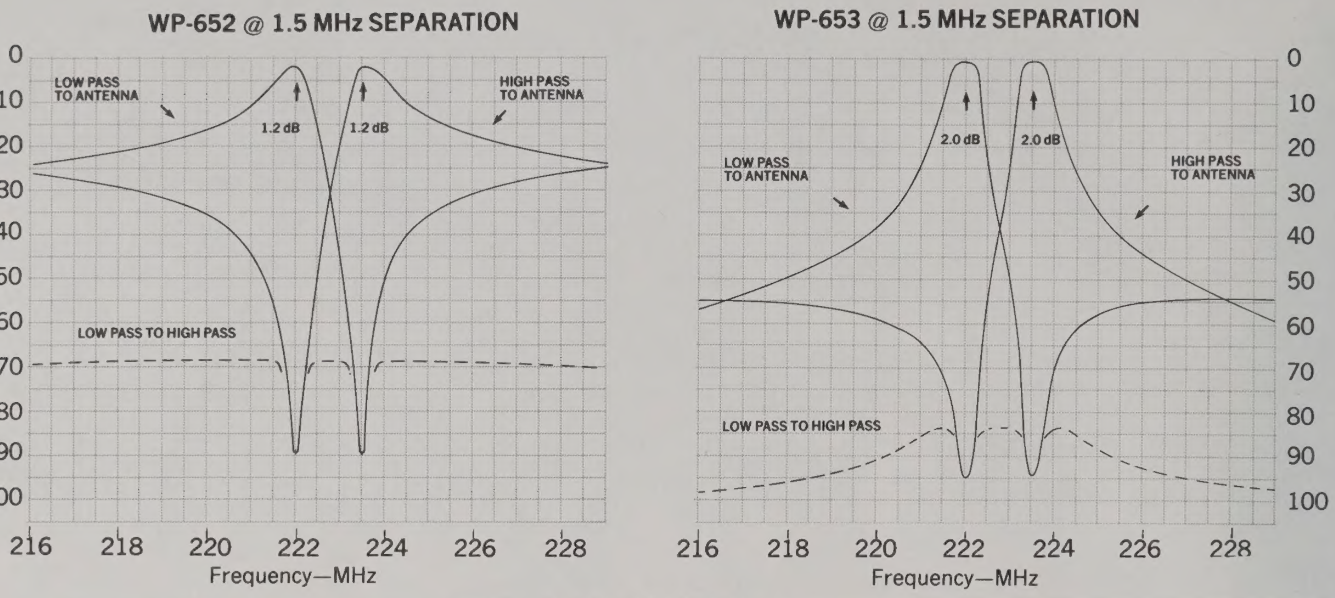
## WACOM PRODUCTS, INC.

# TYPICAL DUPLEX RESPONSE CURVES


WP-652 @ 1.5 MHz SEPARATION

WP-653 @ 1.5 MHz SEPARATION

## ELECTRICAL DATA

| | Model WP-652 | Model WP-653 |
|---|---|---|
| **Frequency Range** | 220-300 MHz | 220-300 MHz |
| **Minimum Frequency Separation** | 1.0 MHz or more | 1.0 MHz or more |
| **Maximum Power Input** (continuous duty) | 350 watts | 350 watts |
| **Insertion Loss** (Tx and Rx to Antenna) | | |
| at 1.0 MHz separation | 1.5 dB | 2.2 dB |
| at 1.5 MHz separation | 1.2 dB | 2.0 dB |
| at 5.0 MHz or more separation | 1.2 dB | 2.0 dB |
| **Isolation** at Tx Freq. and Rx. Freq. | | |
| at 1.0 MHz separation | 85 dB | 90 dB |
| at 1.5 MHz separation | 90 dB | 95 dB |
| at 5.0 MHz or more separation | 95 dB | 100 dB |
| **Isolation** (midway between channels) | | |
| at 1.0 MHz separation | 50 dB | 65 dB |
| at 1.5 MHz separation | 60 dB | 80 dB |
| at 5.0 MHz or more separation | 85 dB | 100 dB |
| **Maximum VSWR** (Ref. 50 ohms) | 1.3 to 1 | 1.3 to 1 |
| **Temperature Range** | –30° to +60°C | –30° to +60°C |
| **Number of Cavity Filters** | 4 | 6 |

## MECHANICAL DATA

| | Model WP-652 | Model WP-653 |
|---|---|---|
| **Dimensions** | | |
| Individual Cavity (not incl. tuning rods) | 5″ OD x 17″ | 5″ OD x 17″ |
| Duplexer (D x W x H) with tuning rods fully extended | 13″ x 17″ x 22″ | 13″ x 22″ x 22″ |
| **Connector Terminations** (Tx, Rx, Ant) | UHF Female (Type N optional) | UHF Female (Type N optional) |
| **Finish** | Gray enamel | Gray enamel |
| **Net Weight** | 22 lbs. | 30 lbs. |
| **Shipping Weight** | 29 lbs. | 38 lbs. |

WACOM PRODUCTS

## ORDERING INFORMATION

**Model WP-652** Duplexer with Tx on______MHz and Rx on______MHz
**Model WP-653** Duplexer with Tx on______MHz and Rx on______MHz

When ordering specify exact Tx and Rx frequency.

# FIELD TUNING INSTRUCTIONS

## BANDPASS/BANDREJECT (BpBr CIRCUIT®) FILTER

## HIGHLIGHTS

(1) The duplexer is factory-tuned to the frequency appearing on the decal. If no frequency was specified on the order, the frequency band will appear on the decal.

(2) To maintain maximum isolation, use double-shielded type cable (RG-142 or RG-214) to connect the duplexer to the transmitter and receiver chassis.

(3) The duplexer includes interconnecting cables between cavities which are critical in length. Do not change.

(4) With some transmitters, the length of the cable between the transmitter chassis and the duplexer might have to be optimized to obtain a proper impedance match (see instructions).

## INSTALLATION

The three input connectors are marked "Low Freq. Input", "High Freq. Input" and "Antenna". If the transmit frequency is lower than the receive frequency, the transmitter should be connected to the connector marked "Low Freq. Input" and the receiver connected to the connector marked "High Freq. Input". If the transmit frequency is higher than the receive frequency, the transmitter should be connected to the connector marked "High Freq. Input" and the receiver connected to the input marked "Low Freq. Input".

## EQUIPMENT REQUIRED FOR FIELD ALIGNMENT

The duplexer is factory-tuned to the exact operating frequencies prior to shipment from the factory. No further field tuning or adjustment is normally required. If it becomes necessary to change the operating frequencies of the duplexer, it can be field tuned if a spectrum analyzer with a tracking generator is available.

## EXPLANATION OF TUNING ADJUSTMENTS

For proper alignment, each of the cavity filters in the duplexer must be tuned to two different frequencies: (1) the frequency to be passed by the cavity and (2) the frequency to be attenuated or rejected by the cavity. In addition, the loop assembly can be rotated to adjust for insertion loss. An increase in the insertion loss will result in an increased selectivity response. The threaded Invar tuning rod is the "pass" frequency adjustment and the variable capacitor is the "reject" frequency adjustment. The reject frequency adjustment (capacitor) must always be the last adjustment made to each cavity. Adjustment of the capacitor moves the notch (reject frequency) closer to, or farther from the pass frequency but does not change the pass frequency alignment. Rotation of the threaded tuning rod changes alignment of the "pass" frequency as desired, but also changes alignment of the notch to some unknown frequency. For this reason, the "pass" frequency adjustment is made first and the "reject" frequency adjustment is made last.

Cavities 1 & 2 are always tuned to pass the lower of the two frequencies and reject the higher of the two frequencies. Cavities 3 & 4 are always tuned to pass the higher frequency and reject the lower frequency. All four cavities have the same power handling capability therefore either section of the duplexer can be used for transmitter or receiver.

## PREPARE THE CAVITIES FOR REALIGNMENT (Pretune)

NOTE: These first 6 steps are preliminary steps and a high degree of accuracy in the frequency or amplitude is not required. Even though high accuracy is not needed, these steps are necessary in order to obtain accuracy in the final steps of tuning the duplexer.

(1) Connect the equipment as shown in Figure 1. Adjust analyzer sweep setting as to include full response curve (see Figure A).

(2) Loosen the hex nut which locks the threaded tuning rod on the cavities and rotate the threaded tuning rod of cavities 3 & 4 for maximum signal (minimum loss) into the analyzer at the pass frequency.

(3) Remove the slotted dust cap from capacitors C & D and tune capacitors to obtain rejection notches symmetrical about the center frequency as illustrated by Figure A.

## PREPARE THE CAVITIES FOR REALIGNMENT (Pretune) (continued)

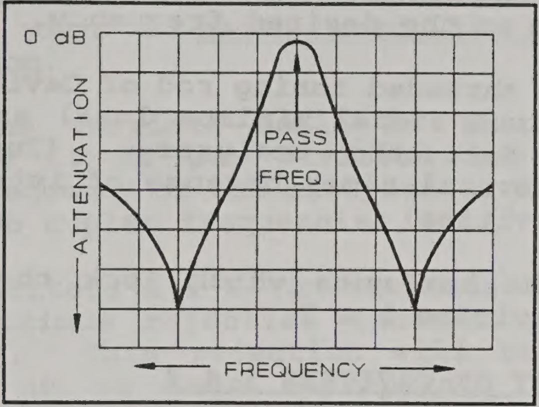


Figure A

(4) Connect the equipment to the duplexer as shown in Figure 2.

(5) Rotate the threaded rods on cavities 1 & 2 for maximum signal (minimum loss) into the analyzer at the pass frequency.

(6) Remove the slotted dust cap from capacitors A & B and tune capacitors to obtain rejection notches symmetrical about the center frequency as illustrated by Figure A.

The duplexer is now in the proper preliminary state to "fine tune" the duplexer to the duplex frequencies.

NOTE: For all "fine tune" steps use horizontal and vertical scales on the analyzer which will yield highly accurate and reliable frequency and amplitude measurements. We recommend a frequency sweep width of no greater than is required to see the -3 Db points and an amplitude scale no greater that 2 dB per division for insertion loss measurements.

## TUNE "PASS" FREQUENCY OF CAVITIES 1 & 2

(7) Set the analyzer center frequency to the lower of the two duplex frequencies. Be sure setting is exactly on the desired frequency.

(8) Rotate the threaded tuning rod of Cavities 1 & 2 for maximum signal(minimum loss) at center frequency into the analyzer. (Tune both cavities several times because of interaction between cavities)

(9) Tighten the hex nuts which lock the tuning rods of Cavities 1 & 2.

## TUNE "PASS" FREQUENCY OF CAVITIES 3 & 4

(10) Reconnect the equipment as shown in Figure 1.

(11) Set the analyzer center frequency to the higher of the two duplex frequencies. Again, make sure setting is exactly on the desired frequency.

(12) Rotate the threaded tuning rod of Cavities 3 & 4 for maximum signal(minimum loss) at center frequency into the analyzer. (Tune both cavities several times because of interaction between cavities)

(13) Tighten the hex nuts which lock the tuning rods of Cavities 3 & 4.

## RE-TUNE "PASS" FREQUENCY OF CAVITIES 1 & 2

(14) Repeat Steps 7, 8 & 9. This is a precautionary step to insure that Cavities 1 & 2 are properly tuned. This Step 14 is not necessary if the duplexer is being re-tuned to new frequencies that are close to the old frequencies. Step 14 is mandatory if the new "pass" frequency of Cavities 1 & 2 is close to the old "pass" frequency of Cavities 3 & 4.

(15) Tighten the hex nuts which lock the tuning rods of Cavities 1 & 2.

## TUNE "REJECT" FREQUENCY OF CAVITIES 1 & 2

(16) Connect the equipment as shown in Figure 3. Be sure to terminate the "Antenna" port of the duplexer with a known good 50 ohm load termination.

(14) Change the vertical scale of the analyzer system to 10 dB per division and set the center frequency of the analyzer to the higher of the two duplex frequencies.

(15) Tune capacitors A & B (on cavities 1 & 2) to obtain maximum rejection (notch) at center frequency. This rejection will be greater than 70 dB so take appropriate steps to increase the sensitivity/dynamic range of your analyzer system to accurately tune the rejection notch.

## TUNE "REJECT" FREQUENCY OF CAVITIES 3 & 4

(16) Leave the equipment connected as shown in Figure 3.

(14) Set the center frequency of the analyzer to the lower of the two duplex frequencies.

(15) Tune capacitors C & D (on cavities 3 & 4) to obtain maximum rejection (notch) at center frequency. This rejection will be greater than 70 dB so take appropriate steps to increase the sensitivity/dynamic range of your analyzer system to accurately tune the rejection notch.

The duplexer is now tuned and ready to use.

## SETTING OF COUPLING LOOPS

The duplexer is shipped from the factory with the coupling loops on each cavity preset for a specific insertion loss provided by the customer at time of order. If adjustment is needed, the cavities will have to be changed on an individual basis; i.e. one cavity at a time.

IMPORTANT: When removing the cavity-to-cavity interconnect cables be sure to return each cable to its original location in the duplexer.

(1) Disconnect the duplexer interconnect cables and set the analyzer center frequency to the appropriate pass frequency for the specific cavity. Connect analyzer input and output cabling to the "Tee" of the individual cavity. Cavities 1 & 2 are always tuned to pass the lower of the two frequencies and Cavities 3 & 4 are always tuned to pass the higher frequencies.

(2) Loosen the hex nut which locks the threaded tuning rod on the cavity and rotate for maximum signal (minimum loss) into the analyzer at the appropriate pass frequency.

(3) Remove the slotted dust cap from the variable capacitors and tune capacitor to obtain rejection notches symmetrical about the appropriate center frequency as illustrated by Figure A.

(4) Take note of the notch separation bandwidth in order to have a base setting to go back to if need be.

(5) Loosen the three screws on the connector disc and rotate disc for the insertion loss desired. The connector disc can be rotated in either direction as long as movement from origninal position does not exceed ±¼ turn. Tighten the loop disc screws. NOTE: As notch separation bandwidth increases, insertion loss decreases and vice-versa. Both cavities in a path should be set to the same insertion loss.

(6) The duplexer must always be retuned after the loop settings have been changed.

(7) Reconnect the duplexer's interconnect cabling and repeat steps for Pretune, Tune of the "pass" and Tune of the "reject".

IMPORTANT: Be sure to return each interconnect cable to its original location in the duplexer.

SETTING OF COUPLING LOOPS (continued)

(8) Check for desired insertion loss, if undesired loss is evident repeat setting of coupling loop procedures.

## CABLE LENGTH BETWEEN TRANSMITTER AND FILTER

The length of the coaxial cable between the transmitter and the filter (or first cavity in a multi-cavity filter) might be a critical length with some transmitters because of an impedance mismatch. (All transmitters do NOT have a 50 ohm output impedance) In this event, the length of cable will have to be optimized. The need for this optimization will be apparent if the output power of the transmitter is reduced by more than the amount absorbed in the cavity(s) due to insertion loss. (Note that ½ dB insertion loss = transmitter power loss of 11%; 1 dB = 20%; 1.5 dB = 29%; 2 dB = 37%; 3 dB = 50%)

The optimum length of cable between the transmitter and the duplexer can be found by the following procedure:

(1) Cut a length of RG-214 or equivalent type cable to the approximate length that will be required to interconnect the transmitter to the duplexer. Attach connectors and connect to transmitter.

(2) Tune the transmitter into a 50 ohm dummy load (or antenna) according to the instruction book. Insert the duplexer between the transmitter and dummy load (or antenna). If there is an impedance mismatch, the duplexer will detune the transmitter, in this case the cable length should be optimized.

(3) Using short lengths of coaxial cable (approximately 2" @ 450 MHz; 4" @ 150 MHz; 8" @ 70 MHz), or UG-27 right elbow connectors, gradually increase the length of the above coaxial cable between the transmitter and filter over a half-wavelength (at the operating frequency) until the optimum length (no detuning effect) is found. (Note: a UG-27 elbow is equal to approximately 1½" of RG-214 or equivalent type cable). A half-wavelength (RG-214 cable) at the operating frequency can be found by:

$$\begin{array}{c}\textit{Length (inches) of}\\ \textit{½ wavelength (RG-214 cable)}\end{array} = \frac{3892}{\textit{Freq. (Mhz)}}$$

## CABLE LENGTH BETWEEN TRANSMITTER AND FILTER (continued)

Example: At 152.03 MHz, ½ wavelength (RG-214 cable) equals 25.61 inches. Therefore, the random length of cable (above paragraph 3) should be increased approximately 4" at a time, and the transmitter-filter match checked at each length, until a total of 26" of additional cable has been tried. At some length within this 26", the match will be optimized and that length should be noted.

(4) When the proper cable length is found, replace the longer cable length (paragraph 3) and the short lengths of cable and the UG-27 elbows (paragraph 4) with one continuous length of cable of equivalent electrical length. The cable length is now optimized.

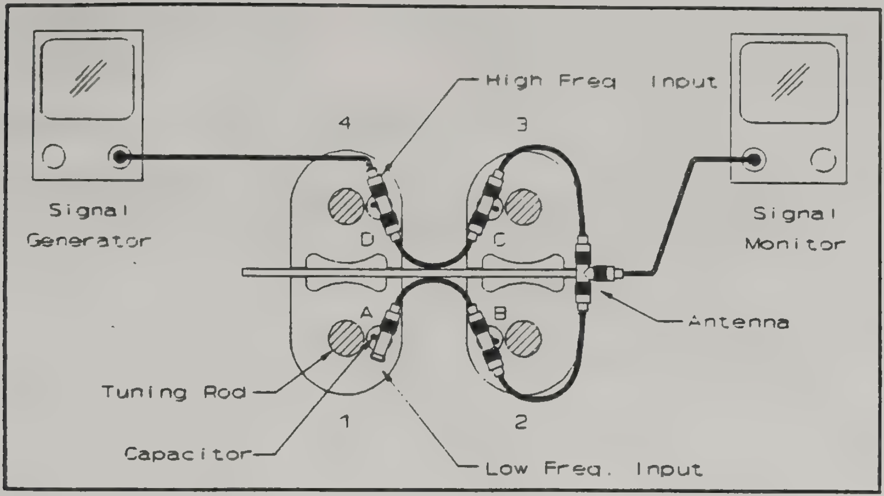


Figure 1

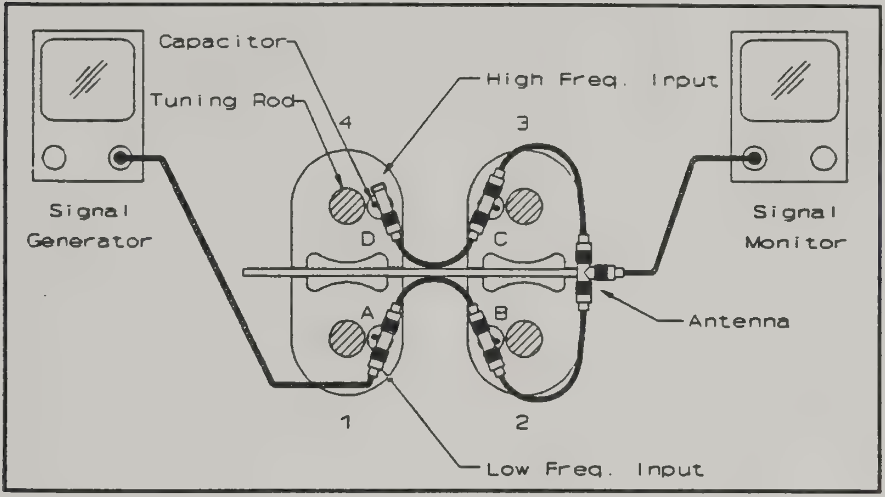


Figure 2

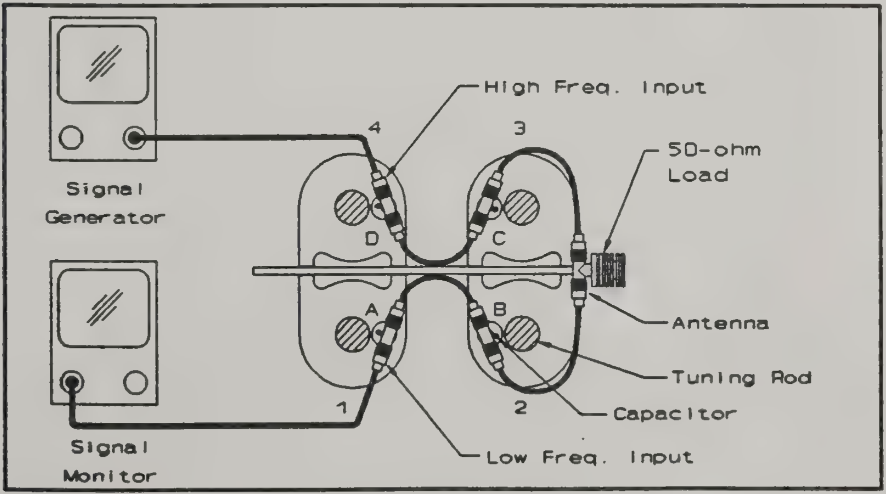


Figure 3

Transmit Freq = 222.4200 MHz
Transmit Power = 4.00 watts

Receive; Freq = 224.0200 MHz
Receive Sensitivity = .2500 uv

Duplexer/Cavity Isolation Required = 71.66 db

Antennas seperated 82 ft vertically or 3042 ft horizontally, may provide the required isolation.

## DUPLEXER TEST SHEET

CUSTOMER: Ski Country Amateur Radio Club
Carbondale Co.

Model No. WP-652

Serial No. 29905

Tx frequency 224.020

Rx frequency 222.420

INSERTION LOSS:

Tx to Ant. 2.2 dB

Rx to Ant. 2.0 dB

Tx to Rx ISOLATION:

At Tx Freq. 97 dB

At Rx freq. 97 dB

Inspector: Turner

Date: 3-11-96